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Long-Term Performance of 137 Stack Gas Continuous Emission Monitors

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16. ABSTRACT

Continuous emission monitoring system operation reports in the files of three air pollution control agencies were examined to determine the frequency, duration and type of malfunctions that cause these systems to become inoperative for regulatory purposes. Eighteen months of operating data were examined for 137 monitors (74 NO_x, 37 SO_2, 7 combination NO_x/SO_2, 8 O_2 and 11 opacity) that had previously passed an acceptance (performance) test identical to EPA monitoring system performance test procedures. Analysis of the data showed that 80% of the monitors operated at least 95% of the time over the eighteen months, with 90% operating at least 90% of the time. Excessive calibration drift and gas conditioning system failure accounted for 51% of the 519 inoperative monitor reports on single-pollutant extractive NO_x and SO_x monitors. Excessive calibration drift along with lamp/detector failure and electrical failure accounted for 62% of the 1054 inoperative monitor reports recorded on the single-pollutant NO_x and SO_x in situ monitors. In contrast, data processor failure was the major cause of malfunction for the O_2 (84%), opacity (74%) and combination NO_x/SO_2 (61%) monitors.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

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Long-Term Performance of 137 Stack Gas Continuous Emission Monitors

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The Texas Air Control Board (TACB), the South Coastal Air Quality Management District (SCAQMD), and the Bay Area Air Quality Management District (BAAQMD) presently use stack gas continuous emission monitoring system (CEM) data to enforce emission standards.[1-3] In this respect, they differ from U.S. Environmental Protection Agency regulations[4,5] which use CEM data only to indicate that the source is properly operating and maintaining an air pollution control device. Otherwise, the regulations are similar. For example, each CEM must pass identical acceptance (performance) testing procedures to show that the CEM is accurate and stable before its output data will be accepted. Also, each source must file quarterly reports describing all instances where the CEM indicated that the emission standard was exceeded. In addition, the quarterly report must identify the time, duration and causes of any lost data due to CEM malfunction and the action taken to correct the malfunction.

Because EPA was considering a regulation that would use CEM output data for demonstrating compliance with emission standards, the files of these three agencies (TACB, SCAQMD, BAAQMD) were examined to assist EPA in developing specifications for the amount of time each CEM would be expected to supply data over a specific period of time (e.g., monthly, annually) when the CEM is used for compliance purposes. For the purpose of our study and in conformance with the three agencies' regulations, if a CEM was known to be supplying erroneous data (e.g., it had failed the daily calibration check and could not be brought into calibration), it was considered to be inoperative or malfunctioning.

Although the three agencies instituted their regulations in 1976, only data for the latest 18 mo calendar period were used for this study to better reflect the present state of the art in CEM performance. The SCAQMD (CA) files were examined in May 1980, the BAAQMD (CA) files in January 1981, and the TACB (TX) files in June 1981. Performance data were obtained on 137 monitors representing a total operating time of 1,600,000 h. The monitors were classified as follows: 74 NO_x, 37 SO_2, 7 combination NO_x/SO_2, 8 O_2, and 11 opacity. Three TACB multi-pollutant monitors (1 SO_2/opacity, 2 $SO_2/NO_x/O_2$/opacity) were excluded from the survey because they were essentially one of a kind monitoring systems.

Data Acquisition and Reduction

The following information was extracted from each agency's files and transferred onto computer cards: name and location of the facility, instrument manufacturer, pollutant and process monitored, CEM detection principle, sampling principle, cause of the malfunction, and date, time, and duration

Table I. Comparison of CEM performance by agency, sampling principle, and type.

	In-situ			Extractive		
	SCAQMD	BAAQMD	TACB	SCAQMD	BAAQMD	TACB
NO_x						
No. units	32	19	1	17	0	7
No. malfunctions	624	300	18	273		36
Avg. h/malfunction	30	14	111	11		4
Total available h	420480	142881	8760	223380		58272
Avg. % data capture	96	97	77	99		99
SO_2						
No. units	10	10	0	4	9	4
No. malfunctions	64	48		57	131	22
Avg. h/malfunction	89	65		11	18	3
Total available h	131400	126853		52560	89706	34944
Avg. % data capture	96	98		99	97	99
SO_2/NO_x						
No. units	2	0	5	0	0	0
No. malfunctions	43		163			
Avg. h/malfunction	27		11			
Total available h	26280		42960			
Avg. % data capture	96		91			
O_2						
No. units	0	0	8	0	0	0
No. malfunctions			150			
Avg. h/malfunction			17			
Total available h			86472			
Avg. % data capture			97			
Opacity						
No. units	0	0	11	0	0	0
No. malfunctions			175			
Avg. h/malfunction			16			
Total available h			104160			
Avg. % data capture			97			

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Table II. Comparison of CEM performance by detection principle, source, and manufacturer.

		SCAQMD		BAAQMD		TACB	
		No.	% Capture	No.	% Capture	No.	% Capture
Principle							
Chemiluminescent	Extractive	4	99	0		4	99
Electrochemical	Extractive	9	98	0		0	
Fuel cell	Extractive	4	99	0		0	
Fuel cell	In-situ	0		0		4	93
Ultraviolet	Extractive	4	99	8	97	7	99
Ultraviolet	In-situ	44	96	29	97	6	89
Infrared	Extractive	0		1	99	0	
Redox	Extractive	0		0		3	93
Transmission	In-situ	0		0		11	97
Source type							
Electric utility boiler		26	95	15	98	26	97
Industrial boiler		14	96	3	95	9	97
Acid plant		5	99	4	97	0	
Kiln (Cement)		0		6	99	0	
Sulfur recovery unit		4	98	6	96	0	
CO boiler (refineries)		0		4	96	1	99
Municipal boiler		16	99	0		0	
Manufacturer							
DuPont		4	99	8	97	5	99
EDC		37	96	28	98	0	
Leeds & Northrop		0		1	99	0	
TECO		2	99	0		8	97
Teledyne		0		0		3	99
Beckman		2	99	0		0	
Envirometric		4	99	0		0	
Theta Sensors		9	98	0		0	
Lear Siegler		7	96	1	88	20	95

of the malfunction. To facilitate data reduction, malfunctions were classified into the following general categories: lamp/detector failure, mechanical failure, electrical failure, excessive calibration drift, stack gas conditioning system failure, data processing system failure, other types of identified outages (e.g., nonroutine inspection, no calibration gas available), and cause unknown.

Verification of Completeness of Agency Data

To determine the completeness and accuracy of each agency's file, 50 to 75% of the facilities reporting data were contacted to confirm that all malfunctions and outages were being reported. Only one company, a utility, acknowledged that it was not reporting all outages. This utility stated that its 26 in situ CEM (24 NO_x and 2 NO_x/SO_2) suffered certain types of malfunctions that were not reported by agreement with the agency's district office. For example, if the monitor indicated that emissions were above the standard, but the facility was able to determine by other means (e.g., fuel usage, dilution air) that its actual emissions were below the standard, a malfunction report was not filed. However, since these were actual malfunctions, this additional information was collected from the CEM vendor's service report file, and the data for this facility were adjusted accordingly. This increased the number of malfunctions for this utility fourfold. (It should be noted that the agency affected denied that there was such an agreement with this utility.)

Results and Discussion

In each region, 80% of the monitors had data capture rates above 95% and 90% had a rate above 90%. (Data capture rate is defined as the percent of time the monitor was producing data compared to the total amount of time that it could have produced data.) Suprisingly, each region had a similar overall average data capture rate, and this data capture rate (97%) was essentially independent of sampling principle (extractive, in situ) and monitor type (opacity, O_2, SO_2, NO_x, SO_2/NO_x) (Table I). It was also essentially independent of facility type, operation/detection principle, and manufacturer (Table II).

These data capture rates seem surprisingly high, but it is important to remember that: the files examined contained data only on CEM that had passed the appropriate EPA performance testing procedure; the real accuracy of the monitor data is not determinable since Reference Method testing is done only on a quarterly, semi-annual, or annual basis; and there was no way to independently confirm that a facility was reporting all CEM malfunctions. However, since similarly high data capture rates have been reported by others,[6,7] it seems reasonable to conclude that these data reflect the general performance that can be expected from a properly operated and maintained CEM when its output will be used for determining compliance with an emission standard.

Table III. Percent distribution and average duration of malfunctions by type and principle.

	Single pollutant								Two pollutants	
	In-situ (SO_2 + NO_x)[a]		Extractive (SO_2 + NO_x)[b]		O_2[c]		Opacity[d]		SO_2/NO_x[e]	
Malfunction	% total	Duration (h)	% total	Duration (h)	% total	Duration (h)	% total	Duration (h)	% total	Duration (h)
Calibration	27	19	29	9	7	3	7	5	8	15
Gas conditioning	2	84	22	15	2	22	1	6	3	36
Lamp/detector	18	31	7	13	0	0	1	12	11	38
Electrical	17	44	9	8	3	32	8	20	9	30
Mechanical	11	44	10	12	4	10	9	10	4	40
Data processing	5	32	5	16	84	17	74	17	61	17
Other identified	8	38	10	17	0	0	0	0	4	20
Unspecified	12	21	8	6	0	0	0	0	1	2
Average		39		12		17		16		22

[a] Represents 72 SO_2 and NO_x CEM with a total of 1054 recorded malfunctions.
[b] Represents 41 SO_2 and NO_x CEM with a total of 519 recorded malfunctions.
[c] Represents 8 O_2 CEM with a total of 150 recorded malfunctions.
[d] Represents 11 opacity CEM with a total of 175 recorded malfunctions.
[e] Represents 7 combined SO_2/NO_x CEM with a total of 206 recorded malfunctions.

Table III, which summarizes both the percentage contribution each malfunction type made to the total number of malfunctions and the average time required to correct the malfunction, shows that excessive calibration drift was the most frequent type of malfunction recorded for both single pollutant extractive and in situ SO_2 and NO_x monitors. For the single pollutant, extractive CEM, calibration drift and gas conditioning system failure (the second most common malfunction recorded for these CEM) accounted for 51% of the 519 recorded malfunctions. For the single pollutant, in situ CEM, calibration drift, lamp/detector failure, and electrical failure (the second and third most frequent types of malfunctions recorded) accounted for 62% of the 1054 recorded in situ CEM malfunctions.

For undetermined reasons, it required, on the average, three times longer to correct the in situ SO_2 and NO_x CEM malfunctions than the extractive CEM malfunctions. Further, the time required to correct a specific type of in situ monitor malfunction was always at least twice as long as the time required for an extractive CEM (Table III).

The most frequent cause of malfunction for the O_2, opacity, and combination SO_2/NO_x monitors was data processor failure, which accounted for 84% of the O_2, 74% of the opacity, and 61% of the combination SO_2/NO_x CEM malfunctions. Each of these three types of monitors had the same average malfunction time (17 h).

At the start of this study, it was hoped that the overall cost of installing and maintaining these CEM could be determined, but no source had this information. One source, a refinery, estimated operation, calibration, and maintenance costs to be $70,000/yr/monitor. It was also hoped that the average time required for a CEM to pass the initial acceptance test could be determined, but such information was also not available. However, according to estimates by EPA Region IX, the majority of CEM passed the initial test.[8]

Acknowledgment

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